2.3.13. Groundspeed/Course/ Altitude Accuracy

2.3.13.1. Purpose

The purpose of this test is to determine the accuracy with which the radar can determine the target's groundspeed, course and altitude in radar modes that provide these parameters and to assess the effect these accuracies have upon intercept tactics.

2.3.13.2. General

For radars with STT or TWS modes, the radar can usually provide target velocity over the ground (groundspeed), course over the ground (will be referred to as course) and altitude. The altitude is usually measured relative to ownship and then added to ownship altitude to get target altitude. The target's barometric altitude should be approximately the same (exactly the same given standard conditions) as the radar derived altitude as long as both the target and the test airplane have the same numbers in the Kohlsman window of their altimeters. For VS modes, only radial closure rate, is provided. This is due to the nature of the doppler rate measurement used to determine the rate. No altitude, groundspeed or course is available because range is not available to calculate the course and groundspeed or to solve the third side of the altitude triangle.

Most airplanes with modern radars are also equipped with Inertial Navigation Systems (INSs)that provide a direct display of course and groundspeed. When the target airplane and/or the test airplane are INS equipped, the INS derived course and groundspeed will be used. The barometric altitude of the target and test airplane will still have to be used. These altitudes will have to be corrected for the instrument error (a laboratory calibration) and position error (derived from flight test). The availability of this data will be assumed for both the test and target airplanes. For a test airplane or target without an INS installed, the observed airspeed, altitude, outside air temperature and externally derived winds aloft will be used to get groundspeed and course over the ground. The instrument and position error corrections for the test and target airplanes will also be required. Approximate winds aloft can be obtained from the local weather office or from Pilot Reports (PIREPs) and will probably be the greatest source of error.

2.3.13.3. Instrumentation

Data cards and an optional voice recorder will be required for this test.

2.3.13.4. Data Required

For the VS mode, closure rate accuracy portion of the test; heading, observed pressure altitude (h_{po}), observed airspeed (V_o), observed outside air temperature (OAT_o) and winds aloft are required for both the target and test airplanes. If an INS derived course and groundspeed are available in either airplane, substitute INS derived course and speed for heading, V_o, OAT_o and winds aloft. Record radar mode, bearing to the target and closure rate. For an STT or TWS mode, record heading, V_o, OAT_o, h_{po} and winds aloft for the target airplane. Record the radar mode and radar derived course, groundspeed and altitude of the target. If an INS is available in the target airplane, substitute INS derived course and groundspeed for heading, V_o, OAT_o and winds aloft.

2.3.13.6. Procedure

Following a maximum detection and maximum acquisition range test, record the target, test airplane and radar derived parameters listed above. The only radar derived parameters available during VS mode testing will be closure rate and bearing to the target. The test airplane parameters will not be needed during TWS or STT mode testing. Record the same parameters during mission relatable intercepts performed during the mission utility and integration tests (to be described). Record the data at both the low airspeeds flown in the maximum range tests (used to conserve fuel as per the flight planning section, 6.0.) and the high airspeeds flown during mission relatable intercepts. In addition, record the target altitude data during the low altitude (clutter environment) portion of the maximum detection range tests. Perform the test in the TWS, STT and VS modes.

2.3.13.7. Data Reduction and Presentation

Given the observed values for pressure altitude, airspeed and temperature; h_{po}, V_o and OAT_o, obtain the same parameters corrected for instrument errors, Δh_{pic}, ΔV_{ic} and ΔOAT_{ic} from empirically derived charts such as figure 5.

$$h_{pi}=h_{po}+\Delta h_{pic} \tag{12}$$

$$V_i=V_o+\Delta V_{ic} \tag{13}$$

$$OAT_i=OAT_o+\Delta OAT_{ic} \tag{14}$$

Obtain the aircraft position error corrections, Δh_{pos} and ΔV_{pos}, from flight test data charts such as figure 6.

$$h_{pc}=h_{pi}+\Delta h_{pos} \tag{15}$$

$$V_c=V_i+\Delta V_{pos} \tag{16}$$

Use h_{pc} and V_c to obtain M_t, the true mach number, from figure 7 and combine with OAT_i to obtain the true outside air temperature, t_a.

$$t_a=\frac{OAT_i\ \textit{(in absolute scale)}}{\left[1.0+0.95\left(\frac{(\gamma-1.0)}{2.0}\right)M_t\right]} \tag{17}$$
$$\gamma=\textit{ratio of specific heats},\ 1.4$$

Use t_a to calculate, the local speed of sound, and combine with M_t to get the true airspeed, V_t.

$$a=\sqrt{\gamma R t_a}$$
$$\gamma=\textit{ratio of specific heats},\ 1.4$$
$$R=\textit{gas constant for air},\ 53.35\ \frac{(ft)(lb_f)}{(lb_m)(^\circ R)} \tag{18}$$
$$V_t=(M_t)(a)$$

Vectorially add the wind and heading/V_t vector to obtain the groundtrack for both airplanes. Vectorially resolve the test airplane groundtrack speed component along the bearing to the target and the target's groundtrack speed along the reciprocal bearing. Add the two to get the actual closure rate.

If INS values are available for either target, use the groundspeed and course as above to vectorially solve for the closure rate.

For TWS or STT modes, use the same procedures above to solve for the target's ground track. Use the h_{pc} for the target to compare to the radar derived data.

Compare the closure rates, groundspeeds, course and altitudes derived above to the radar derived values. The difference between the values will be the radar derived course, speed and altitude error. Relate the magnitude of the error to the utility of the radar as an aid for determining intercept parameters and tactics.

2.3.13.8. Data Cards

Sample data cards are provided as card 17.

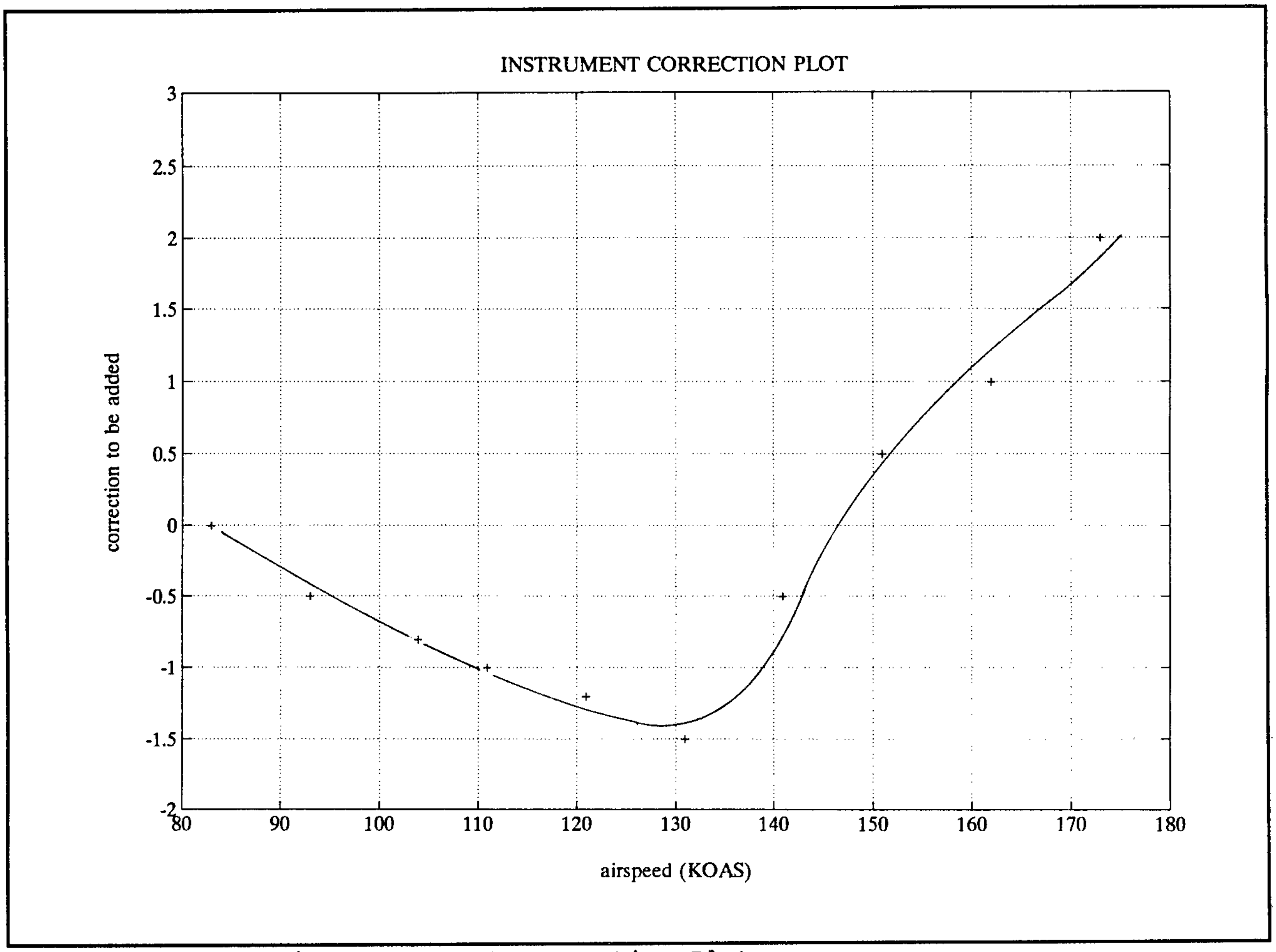

Figure 5: Sample ΔV_{ic} Instrument Correction Plot

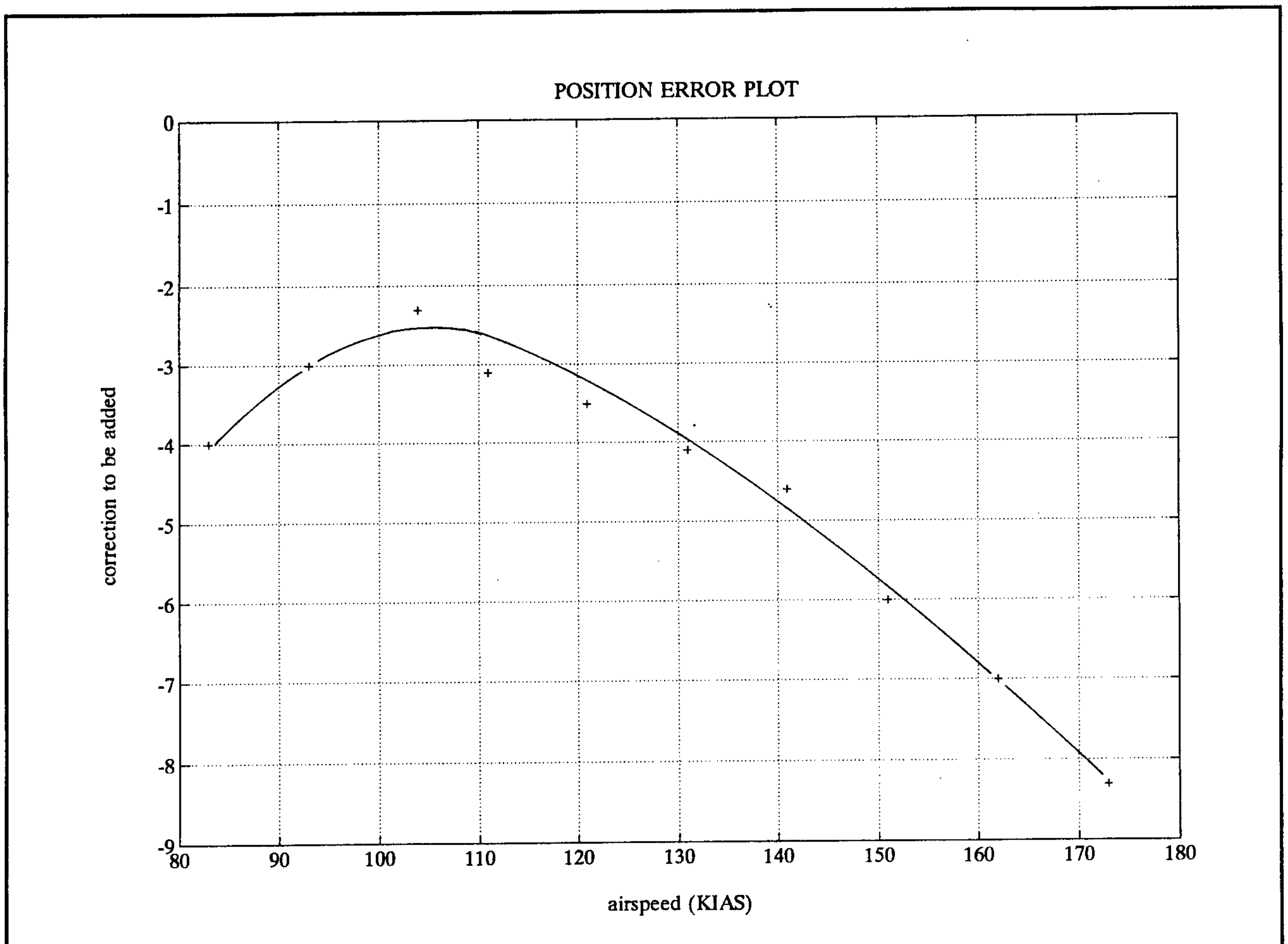

Figure 6: Sample ΔV_{pos} Position Error Plot

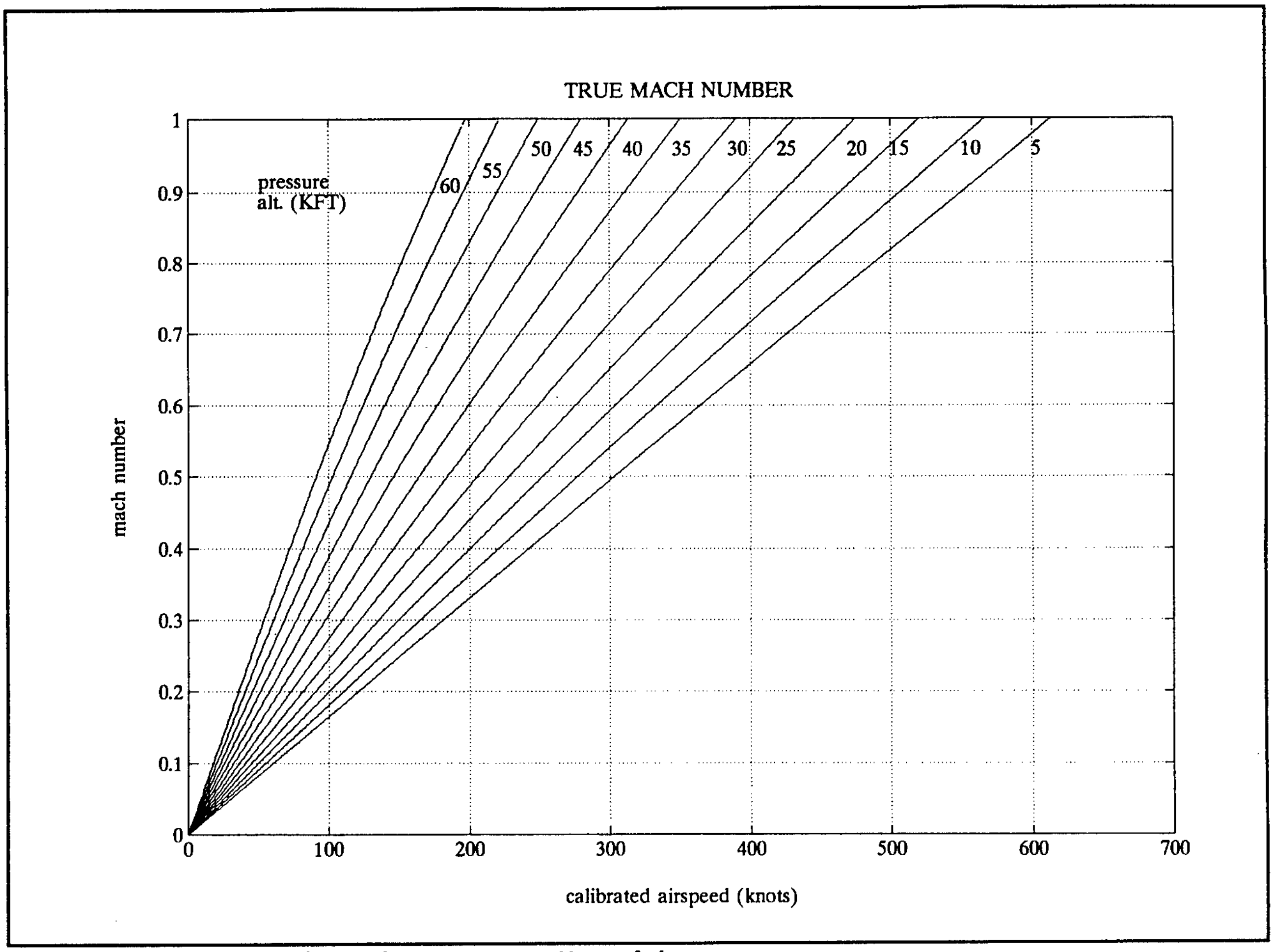

Figure 7: True Mach Number M_t From V_c and h_{pc}

CARD NUMBER ___ TIME PRIORITY L/M/H

GROUNDSPEED/COURSE/ALTITUDE ACCURACY

[FOLLOWING A MAXIMUM ACQUISITION RANGE DATA POINT, RECORD THE DATA BELOW FOR BOTH THE TEST AND TARGET AIRCRAFT. REPEAT FOR LOW AND HIGH ALTITUDE MAXIMUM RANGE TESTING. REPEAT DURING MISSION RELATABLE INTERCEPTS AND MISSION RELATABLE AIRSPEEDS. REPEAT FOR TWS, STT AND VS MODES.]

RUN #	TEST 1	TARGET 1	TEST 2	TARGET 2
MODE				
HEADING				
h_{po}				
V_o				
OAT_o				
WINDS ALOFT				

Card 17: Groundspeed/Course/Altitude Data Cards

GROUNDSPEED/COURSE/ALTITUDE ACCURACY

RUN #	TEST 1	TARGET 1	TEST 2	TARGET 2
RADAR COURSE/BEARING				
RADAR GROUNDSPEED/ CLOSURE RATE				
RADAR ALTITUDE				

[DURING MISSION RELATABLE INTERCEPTS, NOTE THE EFFECTS OF THE TARGET'S COURSE, GROUNDSPEED AND ALTITUDE ACCURACY UPON INTERCEPT TACTICS.]

EFFECTS:

Card 17: Groundspeed/Course/Altitude Data Cards (Continued)